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ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
SITUATION/INTELLIGENCE

1. **SITUATION**

a. **General**. This plan describes the USACE response to a catastrophic earthquake in the Southcentral Alaska region. To qualify as catastrophic under the Federal definition, an earthquake in this region would have to cause severe damage to Anchorage, which is the major population, commerce, and transportation center. (An earthquake in another area of Alaska could cause equally severe local damage, but the total damages would be less, and many of the assets needed for responding to the event would be available from Anchorage and from other areas of the state.) A severe earthquake in Anchorage would also cause damage to the adjacent Matanuska-Susitna and Kenai Peninsula Boroughs, and to the City of Whittier.

This region contains over half the population of Alaska. It is part of one of the most active seismic regions of the world, and has relatively severe winter conditions that can quickly kill persons who are not properly protected.

b. **Threat.** There are two potential sources of catastrophic earthquakes in the region:

(1). Anchorage is located above the inner side of the Alaska-Aleutian Megathrust Fault, a subduction fault that extends south of the Alaskan coast, from Yakutat past the tip of the Aleutian Islands, almost to the Kamchatka Peninsula in Russia. The 1964 Good Friday Earthquake, located on this fault, was the second strongest earthquake worldwide since 1900. (Two others along the same fault rank in the top 10 worldwide for that same period of time.)

(2). Because of the plate movement, Anchorage is in a “crush zone” similar to Los Angeles. This could result in a shallow crustal earthquake of up to magnitude 7.5. Such an earthquake would affect a much smaller area than a subduction earthquake, but the shaking close to the fault could be several times stronger than that produced in 1964. In addition, such an earthquake would have a relatively greater impact on shorter structures, such as residences, than would a subduction earthquake.

c. **Geography.** Anchorage is separated from other population centers. The closest support is from Fairbanks (260 air miles, 350 road miles), which has a total population of around 84,000 persons (including two major military installations, Fort Wainwright and Eielson A.F.B.). Major aid would have to come from the Pacific Northwest, over 3 hours away by air (1446 air miles from Sea-Tac) and several days away by sea or road.

d. **Climate.** Anchorage is in the border region between the maritime Gulf of Alaska region and the continental Interior Alaska region. Nighttime low temperatures below freezing are normal from the end of September until mid-April; high temperatures below freezing are normal from late October until mid-March. Temperatures are noticeably colder in the Matanuska-Susitna (Mat-Su) Valley, as well as in certain “cold spots” within the Anchorage Bowl. See Tab C of Appendix 1 for additional climate information.

<u>ATTACHMENTS:</u>

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- TAB A: GENERAL
  - EXHIBIT 1: REGIONAL DISCRIPTION, 7.5 SHALLOW CRUSTAL EVENT
  - EXHIBIT 2: REGIONAL DISCRIPTION, 8.0 SUBDUCTION EVENT
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APPENDIX 2: ASSESSMENT OF POST-EARTHQUAKE SITUATION
- TAB A: PHYSICAL DAMAGE
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APPENDIX 3: RESIDUAL CONTRACTING CAPABILITY
- TAB A: IDENTIFICATION OF CONTRACTORS IN AREA
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<u>APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP</u>
IMPACTED AREA SITUATION

1. <u>SITUATION</u>

a. **<u>General</u>**. The region has four major political subdivisions:

(1) Anchorage is the major population, commerce, and transportation center in Alaska. The Municipality of Anchorage is a unified home rule government, merging the original Greater Anchorage Area Borough with the Cities of Anchorage, Girdwood, and Glen Alps.

(a) The municipality extends from Girdwood on Turnagain Arm to Eklutna on Knik Arm. Most of the population is in the area from Rabbit Creek to Fort Richardson, with a secondary concentration along the east side of Knik Arm (Eagle River to Eklutna). The total land area is slightly over three times that of the City of Los Angeles.

(b) The Office of Emergency Management is part of the Public Safety Team, reporting to the Municipal Manager. The Municipality's EOC is located at 13th and E. The building survived the 1964 earthquake, and was extensively remodeled in 1999 to serve its new function. The remodeling included structural reinforcement, an emergency power system with 10 days capacity, extensive communications and computer systems, and establishment of the backup police and fire dispatch center in the basement of the EOC building.

(2) The Matanuska-Susitna Borough is north of Anchorage.

(a) This is a second class borough with three incorporated cities: Palmer, Wasilla, and Houston. The Palmer-Wasilla area contains the primary business district of the borough; Palmer also contains the borough government offices and the hospital. The Emergency Management function is located in the Borough Public Safety Department (note: this does <u>not</u> include law enforcement); the EOC is at the Cottonwood Public Safety Building, at the intersection of the Palmer-Wasilla Highway and Seward Meridian Road. The borough and its three cities each have small public works organizations.

(b) Most of the population lives in the Palmer-Wasilla area, but the borough extends out about a hundred miles each way along the Parks and Glenn Highways. In land area, it is the fourth largest local government unit in the United States; it is larger than 9 of the individual states. The Palmer-Wasilla area would be damaged by either of the probable events.

(3) The Kenai Peninsula Borough includes the Kenai Peninsula plus a small area along the west shore of Cook Inlet.

(a) This is a second class borough with six incorporated cities (Kenai, Soldotna, Seward, Homer, Kachemak, and Seldovia); three organized Alaska Native communities (Tyonek, Port Graham, and Nanwalek), and over 20 unorganized communities. The twin cities of Kenai and Soldotna, along with the unincorporated community of Nikiski, form the major economic center of the Borough. Nikiski contains refineries and petrochemical plants. Homer and Seward are also commerce centers, and Seward (at the southern end of the Alaska Railroad) is one of the four primary seaports in mainland Alaska. The total land area of the borough equals that of Massachusetts and New Jersey combined (larger than 9 of the individual states).

(b) The Borough offices are in Soldotna; small hospitals are located in Soldotna, Homer, and Seward. The Borough has an emergency management office, which reports to the mayor. The Borough EOC is in Soldotna; a secondary EOC is located in Seward. The Borough, Kenai, and Soldotna have Public Works Departments.

(c) The Borough would have moderate damage during a subduction earthquake. However, there is a major concern for oil and hazardous materials spills. Direct damage from the shallow crustal event would be primarily along the north shore of the Kenai Peninsula, in the Kenai National Wildlife Refuge. The heaviest damage would probably occur in Hope, a community of about 150 persons located on the south shore of Turnagain Arm, a few miles from the fault. The fault continues across the Sterling Highway, east of Soldotna, between Sterling and Cooper Landing. In addition, some oil wells and production pipelines in the northwestern Kenai Peninsula could be impacted. Land access to Anchorage would probably be cut.

(d) The Kenai-Soldotna area would be damaged by the projected 8.0 subduction zone earthquake. The impacted area contains an active oil production area, including related seaport, refinery, and petrochemical manufacturing facilities. The Kenai-Soldotna includes the majority of the hazardous materials facilities within Southcentral Alaska.

(4) The City of Whittier is in the Unorganized Borough. Access is through a combined railroad-highway tunnel or by sea; the airport is only suitable for light planes. Whittier should escape major damage from either event, and the tunnel remained functional in 1964. However, the city's electrical supply would probably be cut off and the road/rail access could be blocked by avalanches. (These problems occurred during the 1999-2000 Winter Storm and Avalanche disaster.)

b. **Demographics.** About 42% of the population of Alaska (260,283 of 626,932) lives in the Municipality of Anchorage. An additional 9% (59,322) lives in the adjacent Matanuska-Susitna Borough. (27% of the Mat-Su Borough's employed residents work in Anchorage. In addition, 5% work in the North Slope oil fields, and 5% elsewhere; both groups normally commute through Anchorage International Airport.) In addition, 8% of the state's population (49,691) lives in the Kenai Peninsula Borough. Whittier, a second class city in the Unorganized Borough, has about 300 residences.

c. **Logistics.** Anchorage serves as the primary supply point for most of Alaska. The Port of Anchorage and Anchorage International Airport are the primary ocean and air ports for the region. The Port of Anchorage handles 85% of the general cargo for the Alaska Railbelt area.

Anchorage International Airport has a regional hub for Federal Express and a major United Parcel Service facility. In terms of total cargo aircraft landing weight, Anchorage International airport is the busiest air cargo port in the United States, and the sixth busiest in the world. In addition, the seaports of Whittier and Seward rely on the road and railroad routes that run through Anchorage (except for freight to the Kenai Peninsula). Port MacKenzie, a medium-draft port on the west side of Knik Arm, is in the area affected by the two planning earthquakes. The majority of the freight into Anchorage is shipped from the Puget Sound area, but direct shipments arrive from a variety of sources in Alaska, the Lower 48, and international locations such as Japan.

d. **Military Significance.** Anchorage is a major military center. Alaska is in a strategic location that allows rapid deployment of aircraft to both Europe and the Western Pacific Ocean. Elmendorf Air Force Base has been designated as the home of one of Air Force's ten fighter Expeditionary Aerospace Force (EAF) lead wings. Elmendorf AFB also supports Eielson AFB for aerial refueling of air transport between CONUS and eastern Asia. Alaska's primary Army unit, the 172nd Infantry Brigade (Separate), has been selected as one of the new Interim Brigade Combat Teams (Striker Brigades). The six IBCTs are designed to provide a rapidly deployable force for contingency operations anywhere in the world. Army personnel from Fort Wainwright and Fort Richardson rely on the Port of Anchorage for deployment of vehicles and other major items; a Joint Mobility Complex on Elmendorf A.F.B. supports the deployment of Army personnel and equipment by aircraft.

e. **Geology.** Anchorage is located in a subduction zone, where the Pacific Plate is moving under the North American Plate. The area has several known local (shallow crustal) faults and is believed to have blind faults, similar to the Los Angeles area. See Tab B for further information on potential earthquake sources. As an additional concern, the volcanoes on the Western side of Cook Inlet could be triggered by an earthquake, if they were in a pre-eruptive stage at the time. (The range of this effect has been estimated at 250 km for the 7.5 shallow crustal earthquake and 750 km for the deep subduction earthquake. It only occurs if the volcano is already progressing towards an eruption, but apparently can occur some months before the eruption would have normally occurred.)

f . **Geography.** Anchorage is separated from other population centers. The closest major support is from Fairbanks, with a total population of around 82,840 persons (including two major military installations, Fort Wainwright and Eielson A.F.B.). Major aid would have to come from the Pacific Northwest, over 3 hours away by air and several days away by sea or road. Access between the Matanuska-Susitna Borough and downtown Anchorage requires crossing the Matanuska River, the Knik River, Peters Creek, Eagle River, and Ship Creek. In addition, the Glenn Highway overpass over the Alaska Railroad at Eklutna does not have an existing bypass, and the junction of the Old and New Glenn Highways has limited bypass via the on/off ramps. All river crossings have at least 3 existing bridges, and Peters Creek, Eagle River, and Ship Creek all have at least one short, low-level crossing where a bridge could be quickly replaced.

g. **Climate.** Anchorage is in the border region between the maritime Gulf of Alaska region and the continental Interior Alaska region. Nighttime low temperatures below freezing are normal from the end of September until mid-April; high temperatures below freezing are normal from late October until mid-March. Temperatures are noticeably colder in the Matanuska-Susitna (Mat-Su) Valley, as well as in certain “cold spots” within the Anchorage Bowl. The City of Whitter and the populated areas in the Kenai Peninsula Borough have a milder climate due to a greater “maritime climate” influence. The upper Turnagain Arm area and Turnagain Pass on the Kenai Peninsula are known for heavy annual snowfalls, and avalanches are often a problem.

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<u>TAB A TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP</u>
GENERAL

1. **<u>GENERAL SITUATION</u>**. As noted below, there are two major threats to Anchorage. Because of the variations in types and areas of damages, the regional descriptions and projected damages are listed separately. Because both would have major impacts on the same areas of Anchorage, response capabilities are the same unless otherwise noted.

2. **<u>THREAT</u>**. Anchorage is located above the inner side of the Alaska-Aleutian Megathrust Fault, a subduction fault that extends south of the Alaskan coast, from Yakutat past the tip of the Aleutian Islands, almost to the Kamchatka Peninsula in Russia.

a. The Alaska-Aleutian Megathrust Fault is formed by the Pacific Plate subducting under the North American Plate. At approximately Yakutat, the plate boundary becomes the Fairweather Fault, a transform fault. (Some Alaskan geologists maintain that the San Andreas Fault is the southern extension of the Fairweather Fault.) This region is the location for the eight strongest earthquakes in the United States since 1900, including three of the ten strongest earthquakes in the world since 1900.

b. The 1964 Alaska Good Friday Earthquake, moment magnitude 9.2, was the second strongest recorded worldwide since 1900. This earthquake was located on a portion of the megathrust fault east of Anchorage Subsequent research has established that such an earthquake involves about 500 years of energy storage on the fault. However, two major current threats exist.

c. Because of the plate movement, Anchorage is in a “crush zone” similar to Los Angeles. This could result in a shallow crustal earthquake of up to magnitude 7.5. Such an earthquake would affect a much smaller area than a subduction earthquake, but the shaking close to the fault could be several times stronger than that produced in 1964. In addition, such an earthquake would have a relatively greater impact on shorter structures, such as residences, than would a subduction earthquake.

d. The portion of the megathrust fault directly under Anchorage could rupture, producing an earthquake of up to magnitude 8.0. This portion of the fault remained locked during the 1964 earthquake. The shaking from this earthquake would be less violent than that from a shallow crustal earthquake. The shaking would be similar in intensity to that in 1964, but with a shorter duration, and it would have a relatively greater impact on taller structures. The rupture zone is estimated at 200 km by 45 km, with the long axis roughly paralleling Knik Arm. Depending on the exact location of the fault rupture, the zone of greatest shaking would extend into the Matanuska-Susitna Borough and/or the Kenai Peninsula Borough.

3. **<u>IMPACTED AREAS</u>**.

a. The 7.5 shallow crustal earthquake would be on a fault that is primarily within the Municipality of Anchorage. If it were to occur on the Border Ranges fault, the northeastern end would be within the MOA, while the southwestern end would be in an essentially undeveloped area on the Kenai Peninsula. Moderate damage would occur in the Palmer-Wasilla area; impacts to the Kenai Peninsula Borough and to Whittier would be primarily due to damage to access routes along Turnagain Arm.

b. The 8.0 subduction earthquake would involve a rupture zone approximately 200 x 45 kilometers. The position in regard to northwest-southeast location is fairly certain, as it is limited by fault characteristics. The position is less certain in regard to the northeast-southwest location. The location selected would cause impacts to both the Palmer-Wasilla and Kenai-Soldotna areas. An earthquake located further southwest on the fault would have greater impact on the Kenai Peninsula Borough, but less impact on the Matanuska-Susitna Borough. Any location involving the fault area under Anchorage would also involve the road and rail access corridor along Turnagain Arm.

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<u>EXHIBIT 1 TO TAB A TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP</u>
REGIONAL DESCRIPTION, 7.5 SHALLOW CRUSTAL EVENT

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery. The following is the background information used to develop the damage estimates for the 7.5 shallow crustal earthquake:

The geographical size of the region is 1,960 square miles and it contains 56 census tracts. There are over 83,000 households in the region and a total population of 226,300 people (1990 Census Bureau data).

There are an estimated 60,000 buildings in the region with a total building replacement value (excluding contents) of 15.166 billion dollars (1994 dollars). Approximately 96% of the buildings (and 76% of the building value) are associated with residential housing.

The replacement values of the transportation and utility lifeline systems are estimated to be 2.693 billion dollars and 0 dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 60,000 buildings in the region which have an aggregate total replacement value of 15.166 billion dollars (1994 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies.

Table 1
Building Exposure by Occupancy Type

		Building Value (millions of dollars)		
Locality Name	Population	Residential	Non-Residential	Total
Anchorage	226,338	11,451	3,716	15,166

In terms of building construction types found in the region, wood frame construction makes up 84% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilites into two groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 7 hospitals in the region with a total bed capacity of 808 beds. There are 168 schools, 7 fire stations, 5 police stations and 1 emergency operation facility. With respect to HPL facilities, there are 7 dams identified within the region. Of these, 1 of the dams is classified as 'high hazard'. The inventory also includes 3 hazardous material sites, 2 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven transportation systems that include highways, railways, light rail (no systems in the area), bus, ports, ferry and airports. There are six utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data is provided in Tables 2 and 3.

The total value of the lifeline inventory is over 0 million dollars. This inventory includes over 133 kilometers of highways, 143 bridges, and 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highways	Major Roads	12	1,334
	Bridges	143	179
	Tunnels	0	0
		Subtotal	1,513
Railways	Rail Tracks	53	292
	Bridges	0	0
	Tunnels	0	0
	Facilities	1	3
		Subtotal	295
Bus	Facilities	0	0
Ferry	Facilities	0	0
Port	Facilities	2	3
Airport	Facilities	22	125
	Runways	27	756
		Subtotal	881
		Total	2,693

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of $)
Potable Water	Pipelines	0	0.00
	Facilities	0	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Waste Water	Pipelines	0	0.00
	Facilities	1	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Natural Gas	Pipelines	0	0.00
	Facilities	2	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Oil Systems	Pipelines	0	0.00
	Facilities	6	0.00
		Subtotal	0.00
Electrical Power	Facilities	12	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Communication	Facilities	53	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
		Total	0.00

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EXHIBIT 2 TO TAB A TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
REGIONAL DESCRIPTION, 8.0 SUBDUCTION EVENT

HAZUS is a regional earthquake loss estimation model that was developed by the Federal Emergency Management Agency and the National Institute of Building Sciences. The primary purpose of HAZUS is to provide a methodology and software application to develop earthquake losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from earthquakes and to prepare for emergency response and recovery. The following is the background information used to develop the damage estimates for the 8.0 subduction earthquake:

The area involved consists of the Municipality of Anchorage plus portions of the Matanuska-Susitna and Kenai Peninsula Boroughs. The HAZUS model did not include damage to the City of Whittier, which is in the Unorganized Borough; however, some damage is possible there as Whittier is near the rupture zone.

The geographical size of the region is 48,833 square miles and contains 91 census tracts. There are over 111,000 households in the region and a total population of 306,800 people (1990 Census Bureau data).

There are an estimated 96,000 buildings in the region with a total building replacement value (excluding contents) of 20.857 billion dollars (1994 dollars). Approximately 97% of the buildings (and 78% of the building value) are associated with residential housing.

The replacement values of the transportation and utility lifeline systems are estimated to be 15.873 billion dollars and 0 dollars (1994 dollars), respectively.

Building and Lifeline Inventory

Building Inventory

HAZUS estimates that there are 96,000 buildings in the region which have an aggregate total replacement value of 20.857 billion dollars (1994 dollars). Table 1 presents the relative distribution of the value with respect to the general occupancies.

Building Exposure by Occupancy Type

		Building Value (millions of dollars)		
Locality Name	Population	Residential	Non-Residential	Total
Anchorage	226,300	11,450	3,720	15,170
Kenai Peninsula	40,800	2,340	550	2,890
Matanuska-Susitna	39,700	2,550	250	2,800
Alaska impacted:	306,800	16,340	4,510	20,860

In terms of building construction types found in the region, wood frame construction makes up 85% of the building inventory. The remaining percentage is distributed between the other general building types.

Critical Facility Inventory

HAZUS breaks critical facilites into two groups: essential facilities and high potential loss (HPL) facilities. Essential facilities include hospitals, medical clinics, schools, fire stations, police stations and emergency operations facilities. High potential loss facilities include dams, levees, military installations, nuclear power plants and hazardous material sites.

For essential facilities, there are 13 hospitals in the region with a total bed capacity of 983 beds. There are 264 schools, 17 fire stations, 10 police stations and 3 emergency operations facilities. With respect to HPL facilities, there are 7 dams identified within the region. Of these, 1 of the dams is classified as 'high hazard'. The inventory also includes 3 hazardous material sites, 2 military installations and 0 nuclear power plants.

Transportation and Utility Lifeline Inventory

Within HAZUS, the lifeline inventory is divided between transportation and utility lifeline systems. There are seven (7) transportation systems that include highways, railways, light rail (no systems in the area), bus, ports, ferry and airports. There are six (6) utility systems that include potable water, wastewater, natural gas, crude & refined oil, electric power and communications. The lifeline inventory data is provided in Tables 2 and 3.

The total value of the lifeline inventory is over 0 million dollars. This inventory includes over 133 kilometers of highways, 143 bridges, 0 kilometers of pipes.

Table 2: Transportation System Lifeline Inventory

System	Component	# Locations/ # Segments	Replacement value (millions of dollars)
Highways	Major Roads	32	10,181
	Bridges	291	403
	Tunnels	0	0
		Subtotal	10,584
Railways	Rail Tracks	64	677
	Bridges	0	0
	Tunnels	0	0
	Facilities	4	12
		Subtotal	689
Bus	Facilities	0	0
Ferry	Facilities	0	0
Port	Facilities	9	14
Airport	Facilities	120	834
	Runways	134	3,752
		Subtotal	4,586
		Total	15,873

Table 3: Utility System Lifeline inventory

System	Component	# Locations / Segments	Replacement value (millions of $)
Potable Water	Pipelines	0	0.00
	Facilities	0	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Waste Water	Pipelines	0	0.00
	Facilities	0	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Natural Gas	Pipelines	0	0.00
	Facilities	1	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Oil Systems	Pipelines	5	0.00
	Facilities	12	0.00
		Subtotal	0.00
Electrical Power	Facilities	5	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
Communication	Facilities	118	0.00
	Distribution Lines	NA	0.00
		Subtotal	0.00
		Total	0.00

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<u>TAB B TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP</u>
MAXIMUM CREDIBLE PLANNING EARTHQUAKE

1. **<u>Background.</u>** Earthquake planning for Anchorage has traditionally been based on a repeat of the 1964 Good Friday Earthquake. However, in recent years scientists have made breakthroughs in understanding plate boundary earthquakes. The 1964 earthquake is now believed to represent approximately 500 years of energy storage along the plate interface, so this particular scenario is not a current threat. However, there are other faults that are a current threat to the Anchorage area. The Castle Mountain Fault, on the west side of Cook Inlet, has also been used in local earthquake exercises.

2. **<u>AREST Study.</u>** In 1996, the Alaska Regional Interagency Steering Committee (RISC) organized the Alaska RISC Earthquake Scenario Team (AREST) to develop a realistic earthquake threat assessment for the Anchorage area. On 29 May, 1997, the AREST met with Alaskan geologists and geophysicists at the University of Alaska Geophysical Institute in Fairbanks. At that meeting, scientists and planners verified that the 1964 scenario was not a short-term threat, and also determined that the Castle Mountain Fault was too far from Anchorage to produce a catastrophic event. However, two potential earthquakes, listed below, were identified as serious near-term threats to Anchorage. The AREST report is included as Exhibit 1, below.

3. **<u>Maximum Credible Planning Earthquakes.</u>** The following two scenarios were identified as having the potential to cause a catastrophic earthquake in Anchorage in the near future:

a. Shallow Crustal Earthquake: Magnitude 7.5. This could be on the Border Ranges Fault, which runs through the Hillside, Eagle River, and Chugiak areas of Anchorage; it could also be on an unknown fault, similar to those involved at Northridge and Kobe. This would produce severe damage in areas close to the fault. Due to the orientation of the local fault systems, such an earthquake could cause severe damage to almost all of the utility and land transportation systems that come into Anchorage. The projected damages are described in Exhibit 1 to Tab A to Appendix 2, below.

b. Alaska-Aleutians Megathrust Fault: Magnitude 8.0, involving the portion of the plate boundary west of the 1964 event, and east of the Cook Inlet volcanic axis. This area did not release in 1964, and it includes the portion of the plate boundary that is directly under Anchorage. The only recorded major earthquake in Alaska that appears to be similar to this event occurred in 1948 in the Shumagin Island area, but two earthquakes greater than magnitude 8 and deeper than 100 kilometers have been reported in the Andes. The peak acceleration would be less than for a shallow crustal earthquake, but the duration would be longer (90 to 120 seconds) and the impacted area would be much greater. In addition to the Municipality of Anchorage, this earthquake would produce major damage in the Matanuska-Susitna Borough, the Kenai

Peninsula Borough, and possibly the City of Whittier in the Unorganized Borough. The projected damages are described in Exhibit 2 to Tab A to Appendix 2, below.

4. **<u>Associated Risks.</u>**

a. Tsunamis. Both events were determined to be unlikely to produce a Tsunami, due to the shallow water in the impacted areas.

b. Avalanches/Landslides. These are probable, especially between Anchorage and the Kenai Peninsula. The Seward Highway and the Alaska Railroad are often blocked by avalanches during the winter, and the avalanche situation was so severe in Southcentral Alaska during the 1999-2000 winter that it resulted in a Federal major disaster declaration.

c. Plumbing damage. During the winter, extended natural gas and/or electrical outages will result in frozen pipes in residences and commercial buildings. Partial repairs will be needed to allow normal use of the buildings. In December, 1975, a power plant fire in the Southwestern Alaska city of Bethel caused freezing damage in almost every building that had water and/or sewer service, resulting in a Federal major disaster declaration.

5. **<u>Limitations on damage predictions.</u>** The default data included with HAZUS does not adequately portray the local situation. While the Municipality of Anchorage has been updating the data base, and the Alaska District updated records on about 450 buildings during a training program in 2000, there are still major gaps. For example, the data does not include electrical and natural gas lines, and two of the four major hospitals in Anchorage have moved into new buildings in the past few years. Local planners believe that HAZUS is under-estimating damages to highways, railways, ports, and airports/runways, as well as over-estimating damage to water, waste water, natural gas, electric power, oil, and communications systems.

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<u>EXHIBIT 1 TO TAB B TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP</u>
AREST REPORT

Alaska RISC Earthquake Scenario Team (AREST)

Purpose

This document describes the “maximum credible” planning earthquakes that will serve as the foundation for two Alaska Regional Interagency Steering Committee (RISC) earthquake response planning scenarios. To achieve scientific consensus on these earthquake descriptions, the Alaska RISC Earthquake Scenario Team *(AREST)* met with Alaskan geologists and geophysicists on May 29, 1997 at the University of Alaska Geophysical Institute in Fairbanks. At that meeting, AREST members and the scientists agreed on two different earthquake events as described below in Table 1.

For the next step of the scenario development, the AREST will provide these earthquake descriptions to technical experts, such as engineers, to define damages most likely to occur. Based on these damages, the AREST will then prepare 2 scenarios designed to test capabilities, plans, resource identification, staging, mass care facilities, and other elements of Federal and State disaster response.

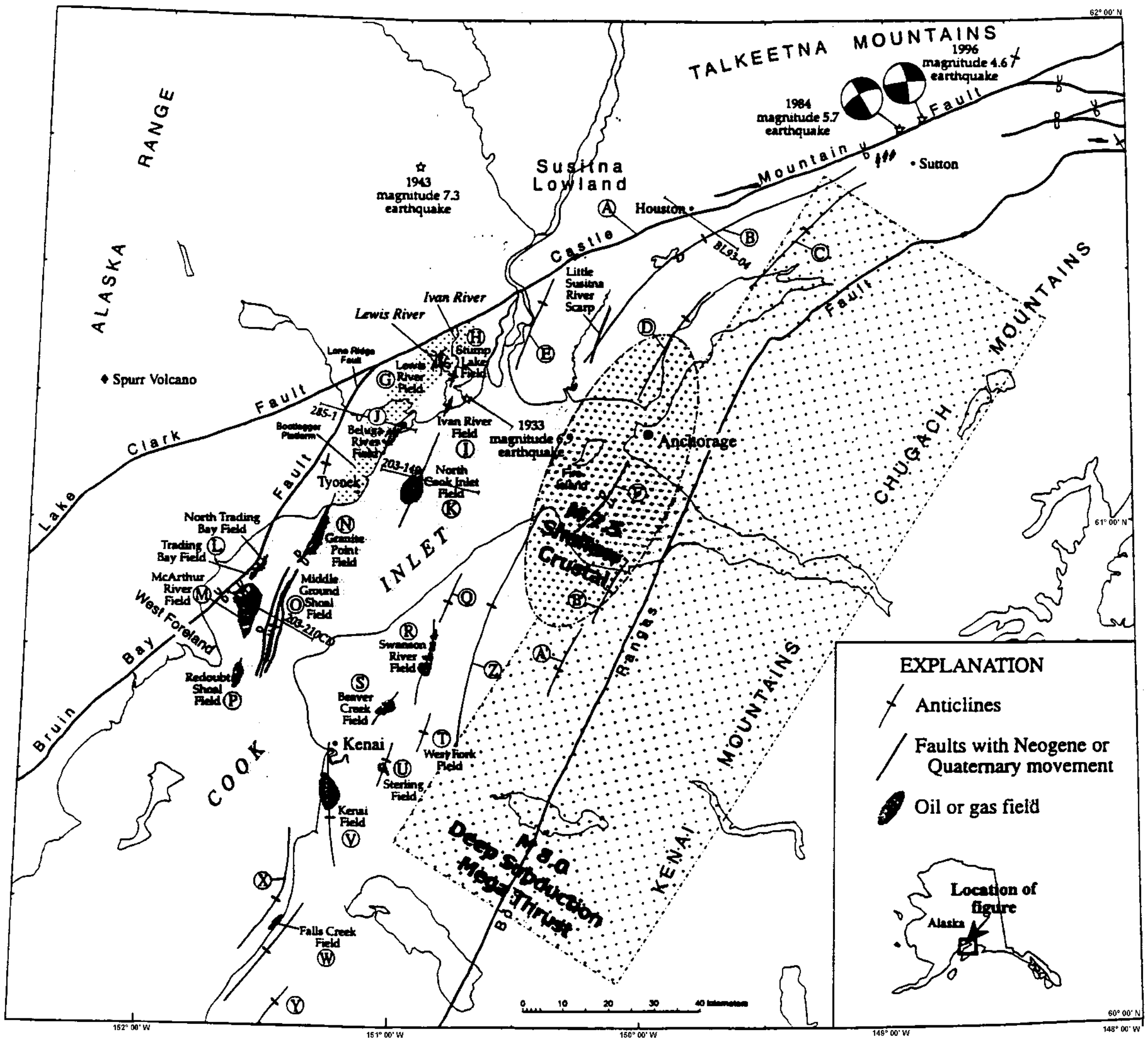
Table 1

Maximum Credible Planning Earthquakes: Anchorage Area
(Likely to occur within 50 years)

	EQ #1	**EQ #2**
Magnitude	M 7.5	M 8.0
Description	Shallow Crustal	Deep Subduction Mega Thrust
Location *(See Figure 1)*	Near Anchorage	Upper Cook Inlet
Depth	3-15 km	40-50 km
Peak Acceleration	0.8g	0.2g
Duration	~40-50 seconds	1 ½-2 minutes
Characteristics	Sudden jolt, then high frequency shaking 1 – 10 cycles/second (1-10 motions/second) 1-10 Hz	Continuous rolling motion 2-5 seconds/cycle (0.2-0.5 motions/second) 0.2-0.5 Hz
Rupture Area	70 x 20 km	200 x 45 km
Secondary Hazards	Land slides Snow avalanches Submarine landslides	Land slides Snow avalanches Submarine landslide
Local Tsunamis	not likely due to shallow water	not likely due to shallow water

Disclaimer: *The earthquakes described here are intended to be used as the foundation for Federal and State response planning. The descriptions provide insufficient data to support any other application.*

Figure 1.
General Areas of Planning Earthquakes



(Haeussler et al.)

Seismic Sources

The Alaska RISC recognizes that Anchorage is not the only Alaskan city in danger of severe earthquakes -- Alaska's location along the Ring of Fire puts the majority of Alaskan communities at risk. The RISC group decided to focus first on the Anchorage and coastal communities because of the large population base and complex problems associated with earthquake response in coastal communities.

As indicated in the *Anchorage Earthquake Sources* table below, Anchorage's earthquake threat is not limited to a single source -- in fact, the greatest threat may be from an unidentified fault. Anchorage is potentially as at risk from a shallow crustal quake as from a larger magnitude subduction earthquake like the 1964 event. Both earthquake types could generate damage sufficient to overwhelm local and state response capabilities. Consequently, the geologists and geophysicists recommended defining two different planning events.

These two "maximum credible" planning earthquakes should be discussed in the larger context of Alaska's immense geological picture. The descriptions should illustrate the seismic consequences of the Pacific plate thrusting under the North American plate. That tectonic activity drives all of the other Alaska mechanisms, including the Castle Mountain Fault, the Border Ranges Fault, the Denali Fault, the strike slip faults in Southeast Alaska, and many others (see Figure 2). It would be negligent to focus on one specific fault when we don't know if Alaska's next damaging earthquake will originate from an unknown fault, a fault previously considered inactive, a known fault, or from the subduction zone.

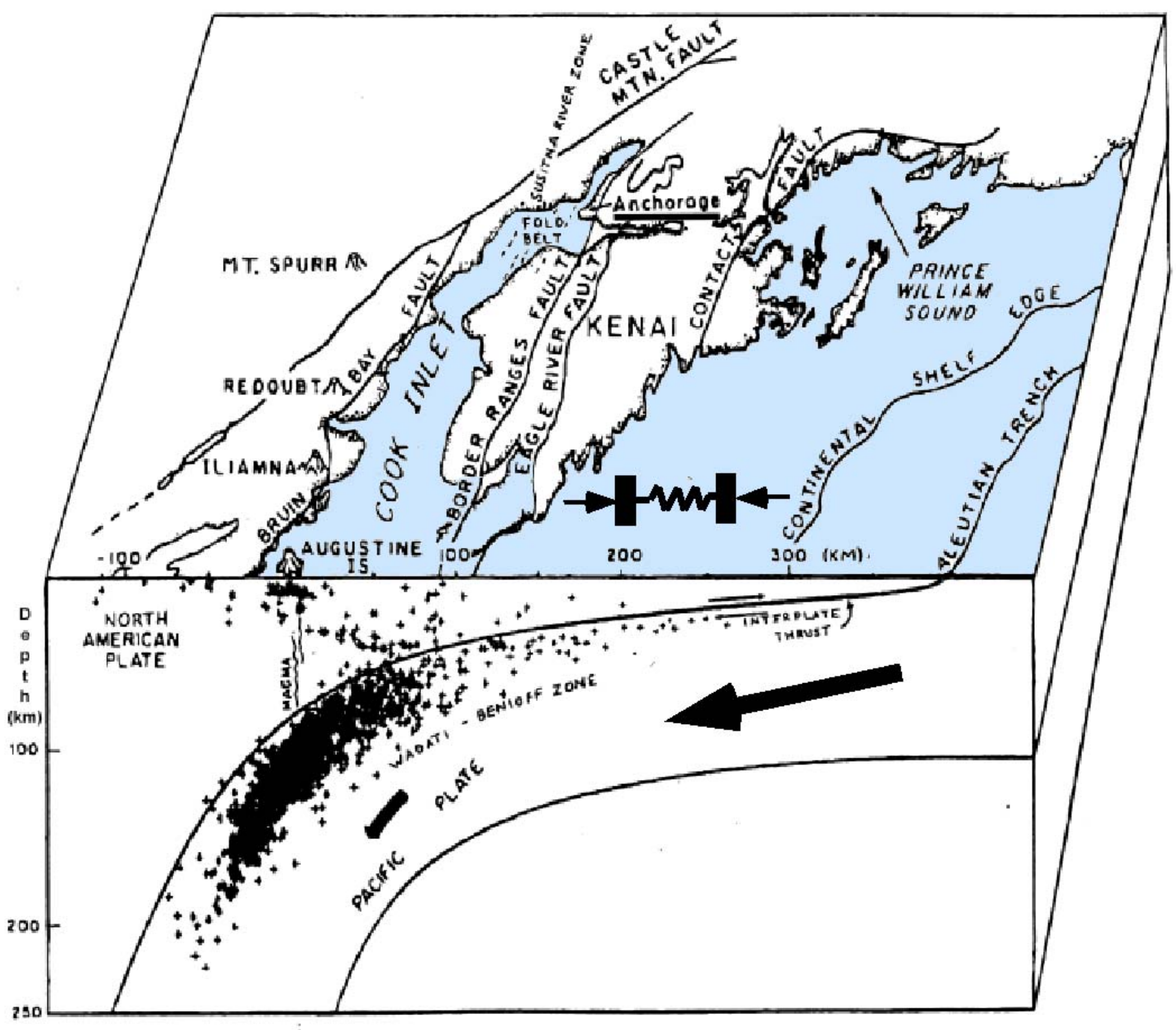
Table 2

Anchorage Earthquake Sources

(Modified from Combellick and Lahr, 1996)

	Maximum Magnitude	Closest Distance to Rupture	Average Return Period
INTERPLATE THRUST			
Shallower than ~20 km	9¼-9½	75 km	600-800 yr
Deeper than ~20 km	8	40-50 km	Unknown
SUBDUCTED PLATE	7-7½	>40 km	Unknown
OVERRIDING PLATE			
Border Ranges fault	7½?	<10 km	>10,000 yr?
N. Cook Inlet fold belt	7?	<10 km	Unknown
Castle Mountain fault	7½-7¾	40 km	1,000 yr?
Susitna River zone	7½	60 km	Unknown
Volcanic axis	6	130 km	Unknown
Other sources	7½	<10 km	Unknown

Figure 2.
Anchorage Seismic Sources
(Combellick & Lahr)



Glossary to Table of Anchorage Earthquake Sources

average return period – the average time interval between earthquakes of maximum magnitude, estimated from seismological and geological data.

interplate thrust – fault contact along which the Pacific plate slides beneath the North American plate.

magnitude – a measure of earthquake size, determined from recorded ground motion and corrected for distance to the event. Common types of magnitude are local (M_L), body wave (m_b), surface wave (M_s), and moment (M_w). As a rule of thumb, the energy released by an earthquake increases by a factor of 32 for each unit increase in magnitude. For example, a magnitude 9 event releases 32 times more energy than a magnitude 8 event.

maximum magnitude – magnitude of the largest earthquake that might reasonably be expected to occur on each source.

N. Cook Inlet fold belt – a zone of folded and faulted rocks in the North American plate which may be the source of a band of shallow earthquakes beneath northern Cook Inlet.

other sources – allows for unknown sources that may be buried or are as yet undiscovered.

overriding plate – Rock material of the North American plate, which is seismogenic from the surface to about 35 km depth.

subducted plate – portion of the Pacific plate that has been thrust beneath the North American plate and continues downward into the mantle, reaching ~100 km below the Aleutian volcanoes. Many earthquakes occur within this plate, creating a pattern of seismicity known as the Wadati-Benioff zone.

Susitna River zone – a diffuse zone of shallow seismicity that extends northward from Cook Inlet to the Alaska Range.

volcanic axis – shallow seismicity associated with the Aleutian volcanic arc, which extends northeastward as far as Mt. Spurr.

Reference

Combellick, R.A., and Lahr, J.C., 1996, Earthquake potential and hazards in southcentral Alaska [abs.]: Geological Society of America Abstracts with Programs, v. 28, no. 5, p. 56-57.

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♥ Thanks to Dale Kloes of FEMA Region 10 for facilitating the Fairbanks meeting and for his contributions to this document – J.R.

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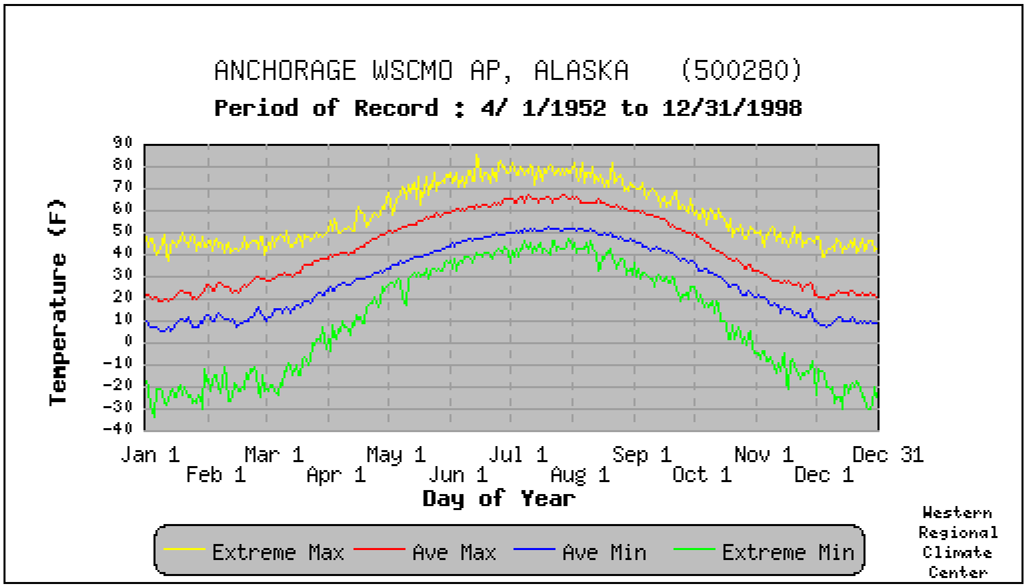
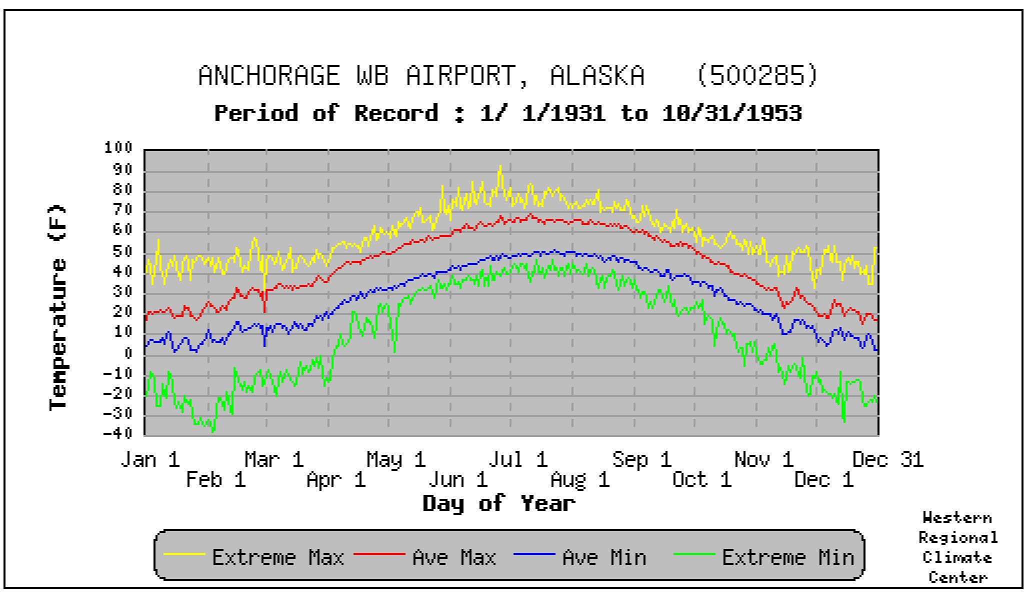
TAB C TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
CLIMATE

Daily Extreme Temperatures—Current Weather Station



Daily Extreme Temperatures—Prior Weather Station



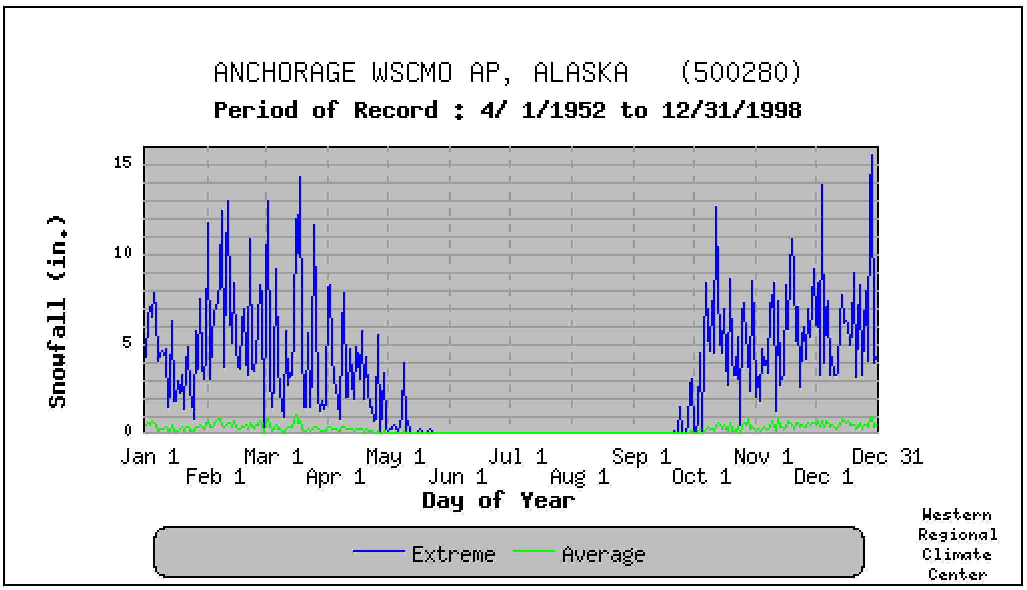
MINIMUM DAILY TEMPREATURES, ANCHORAGE, 1952-1999

	DEC	JAN	FEB
MAX	32.81	27.58	26.93
MEAN	28.91	8.03	11.07
MIN	-7.35	-4.71	-5.00
RECORD	-30	-34	-26

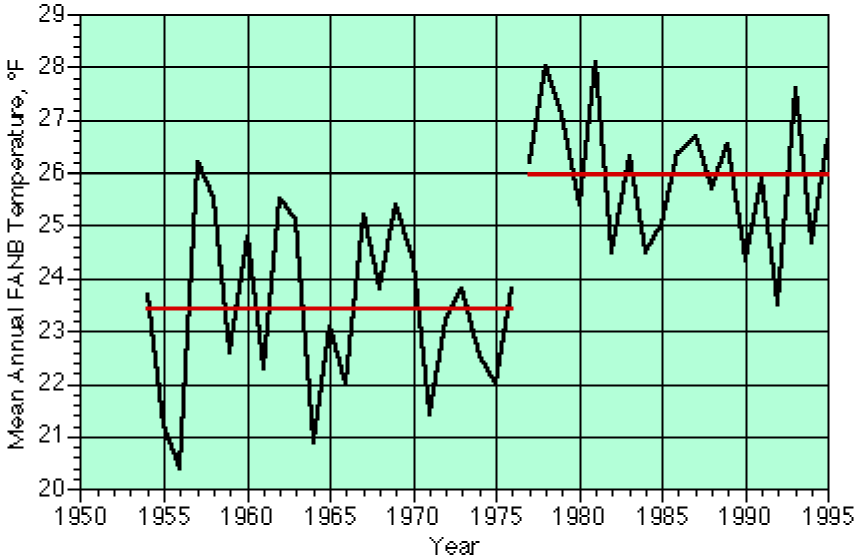
MINIMUM DAILY TEMPERATURES, ANCHORAGE WB, 1931-1953

	DEC	JAN	FEB
MAX	19.26	19.42	25.43
MEAN	7.62	5.41	10.89
MIN	-7.26	-10.39	-5.25
RECORD	-33	-35	-38

(Station was further from Cook Inlet)



Daily Snowfall—Current Weather Station



Mean Annual Temperature, average of Fairbanks, Anchorage, Nome and Barrow, Alaska. Red horizontal lines are averages for 1954-76 and 1977-95.

Note the major increase in temperatures in the 1975-76 time frame. Many meteorologists believe this change is due to a long-term (40+ year) cycle. A similar warm period occurred in the 1934 through 1944 time frame. A return to colder temperatures, during the next 10 or 15 years, would intensify the effects of utilities outages following an earthquake in the Anchorage area.

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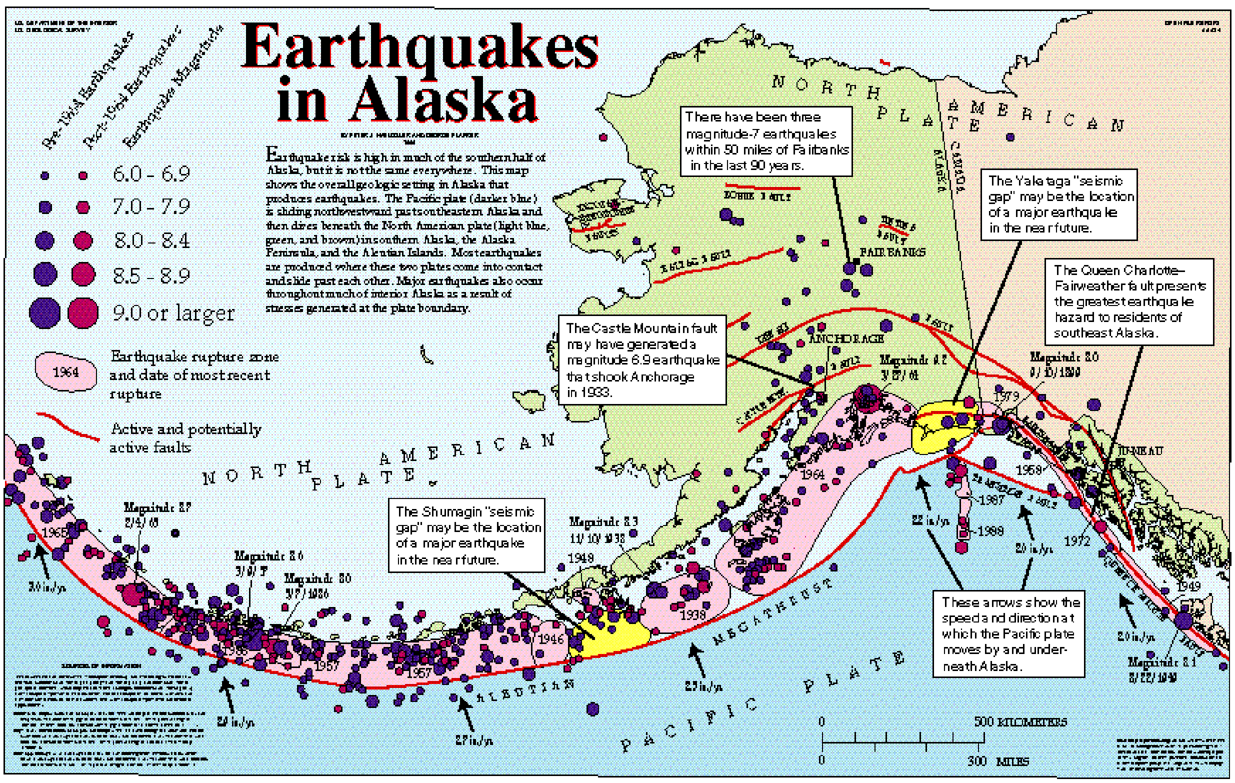
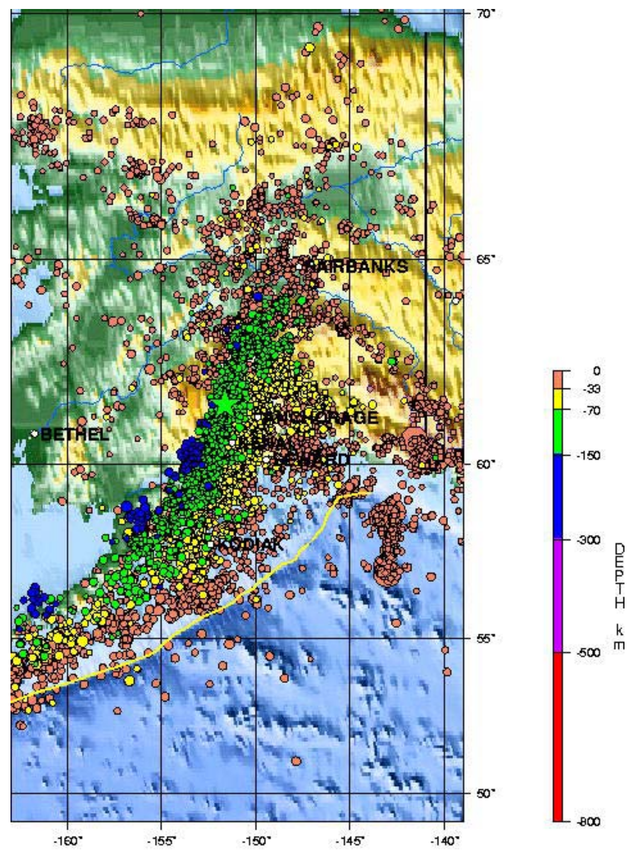
TAB D TO APPENDIX 1 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
MAPS

Seismic zones in Alaska

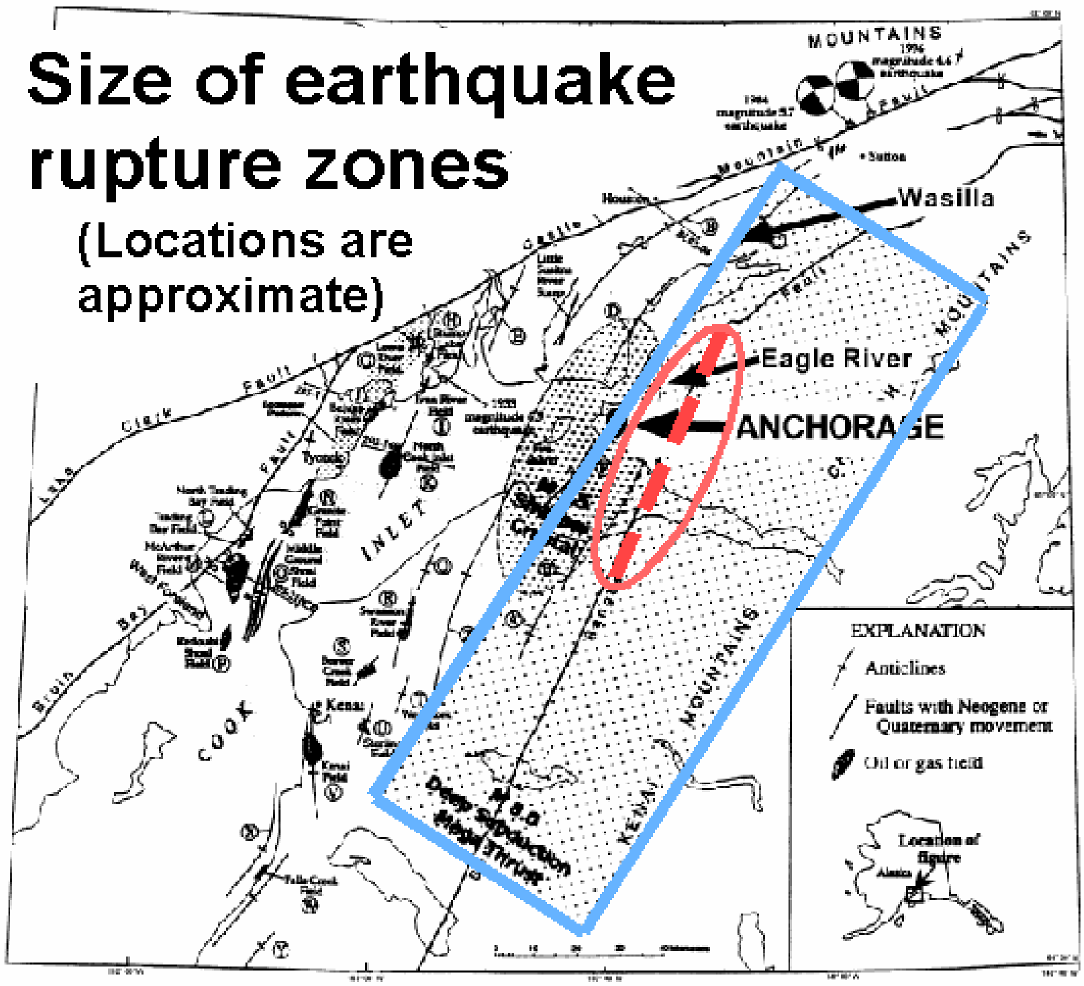


General Areas of Planning Earthquakes

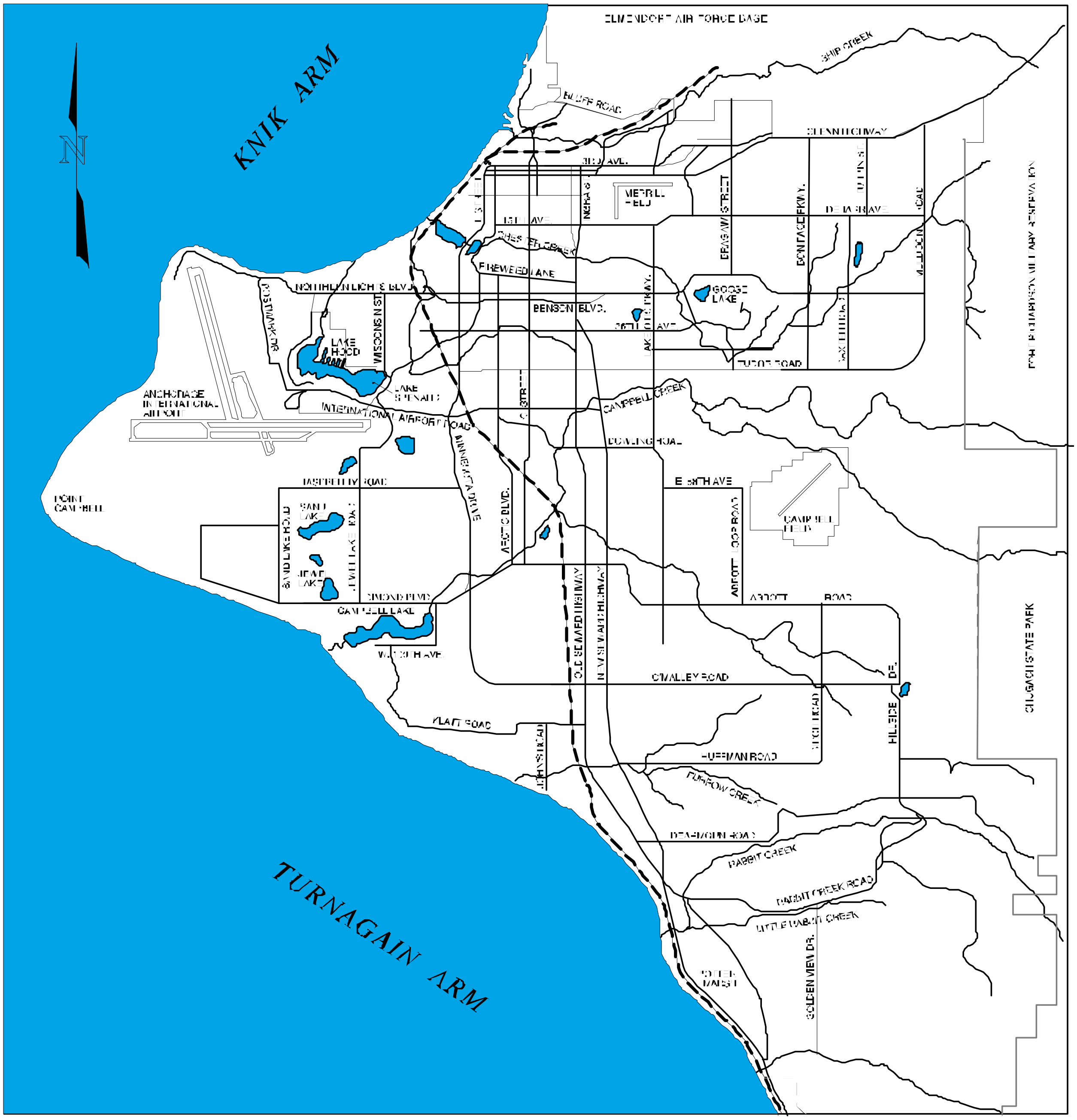
Historical Earthquakes in Southcentral Alaska



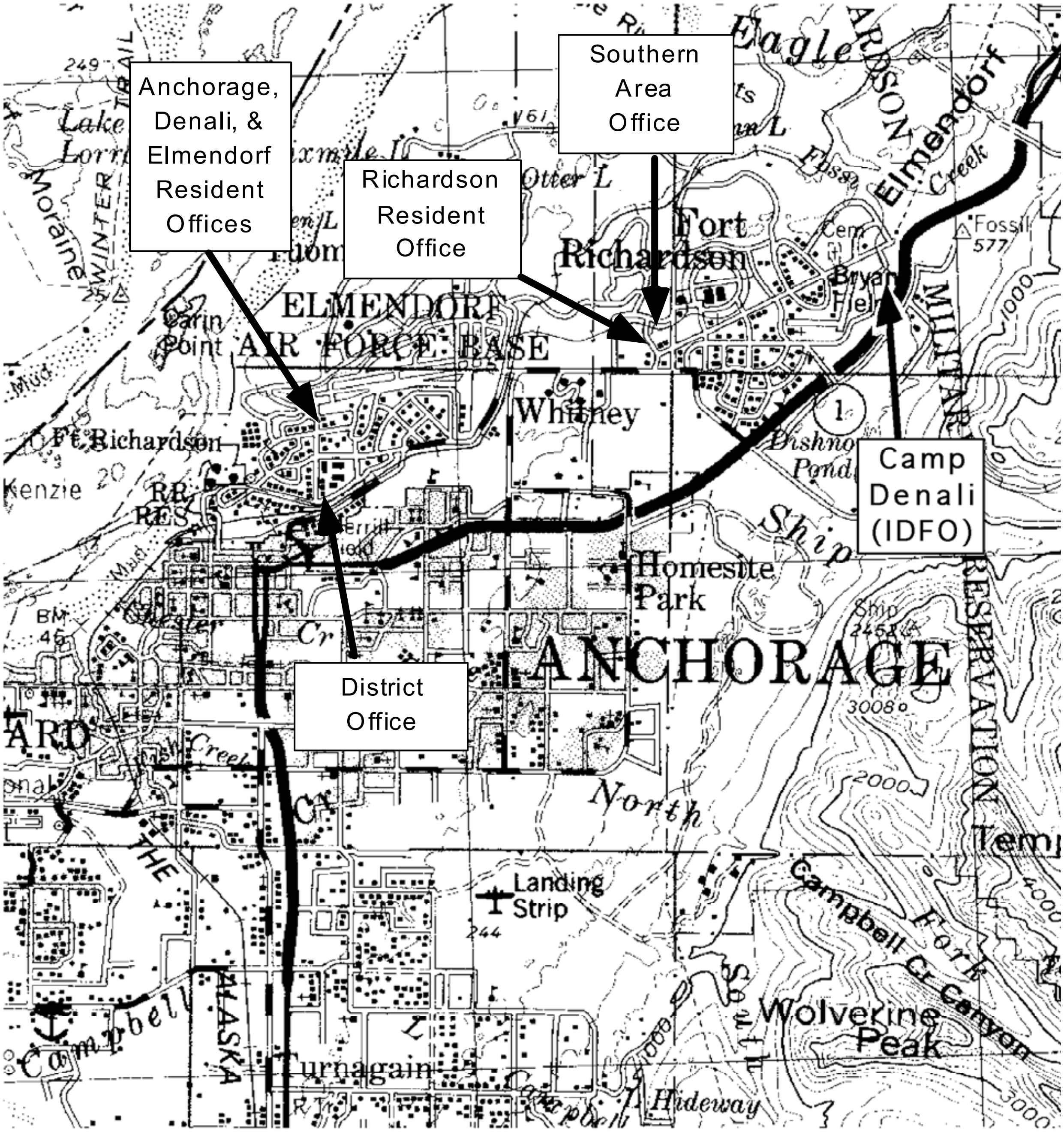
SOUTHERN ALASKA.
2001 03 08 09:27:07.3& 61.542N 151.641W Depth: 85 km 2.4mb
Seismicity 1977 - 1997, Plate Boundaries in Yellow
USGS National Earthquake Information Center


Size of earthquake rupture zones
(Locations are approximate)
Wasilla
Eagle River
ANCHORAGE
Deep Subduction Mega Thrust
EXPLANATION
Anticlines
Faults with Neogene or Quaternary movement
Oil or gas field
Location of figure
COOK
INLET
KENAI
MOUNTAINS

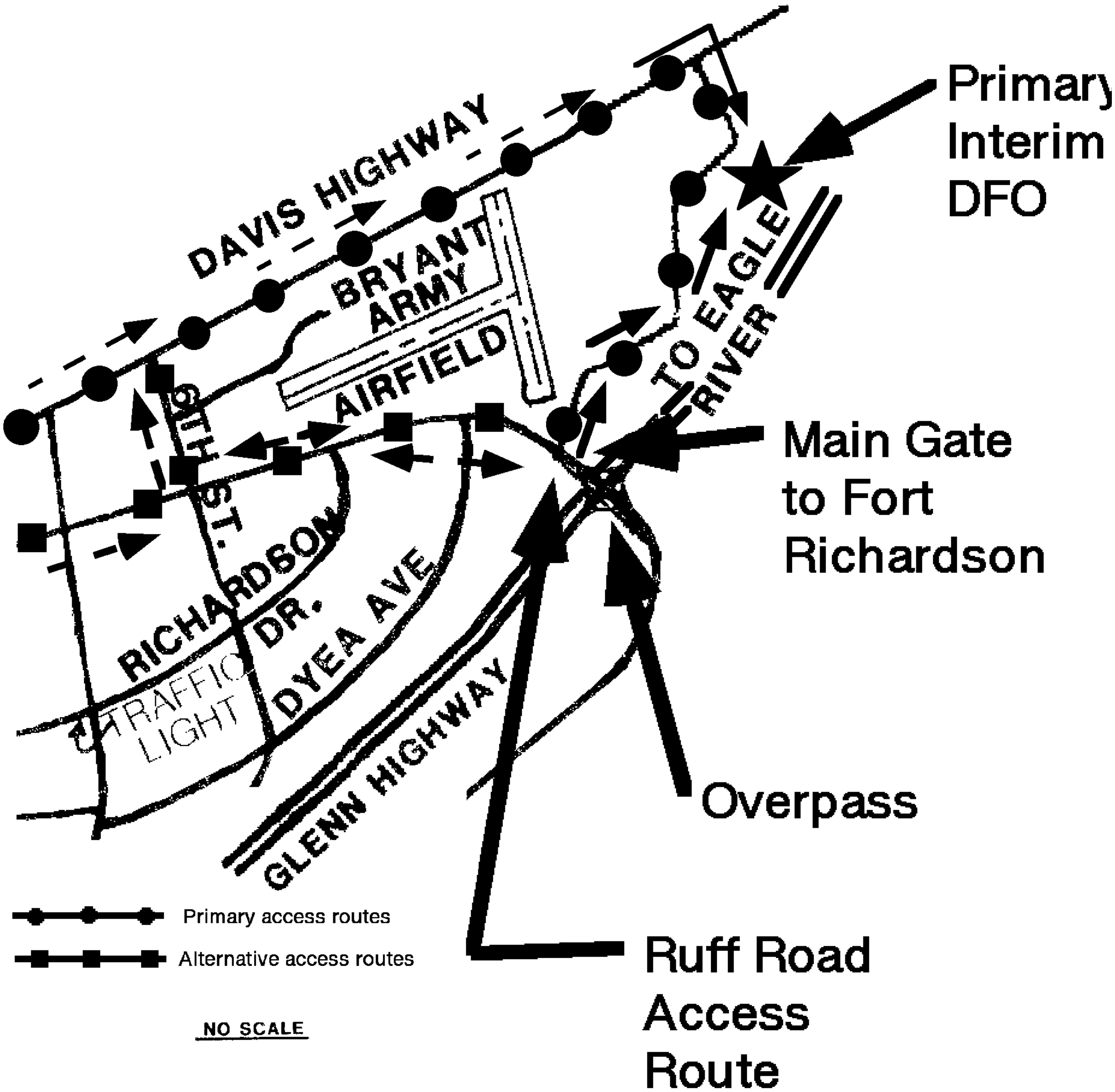
Anchorage Bowl Map



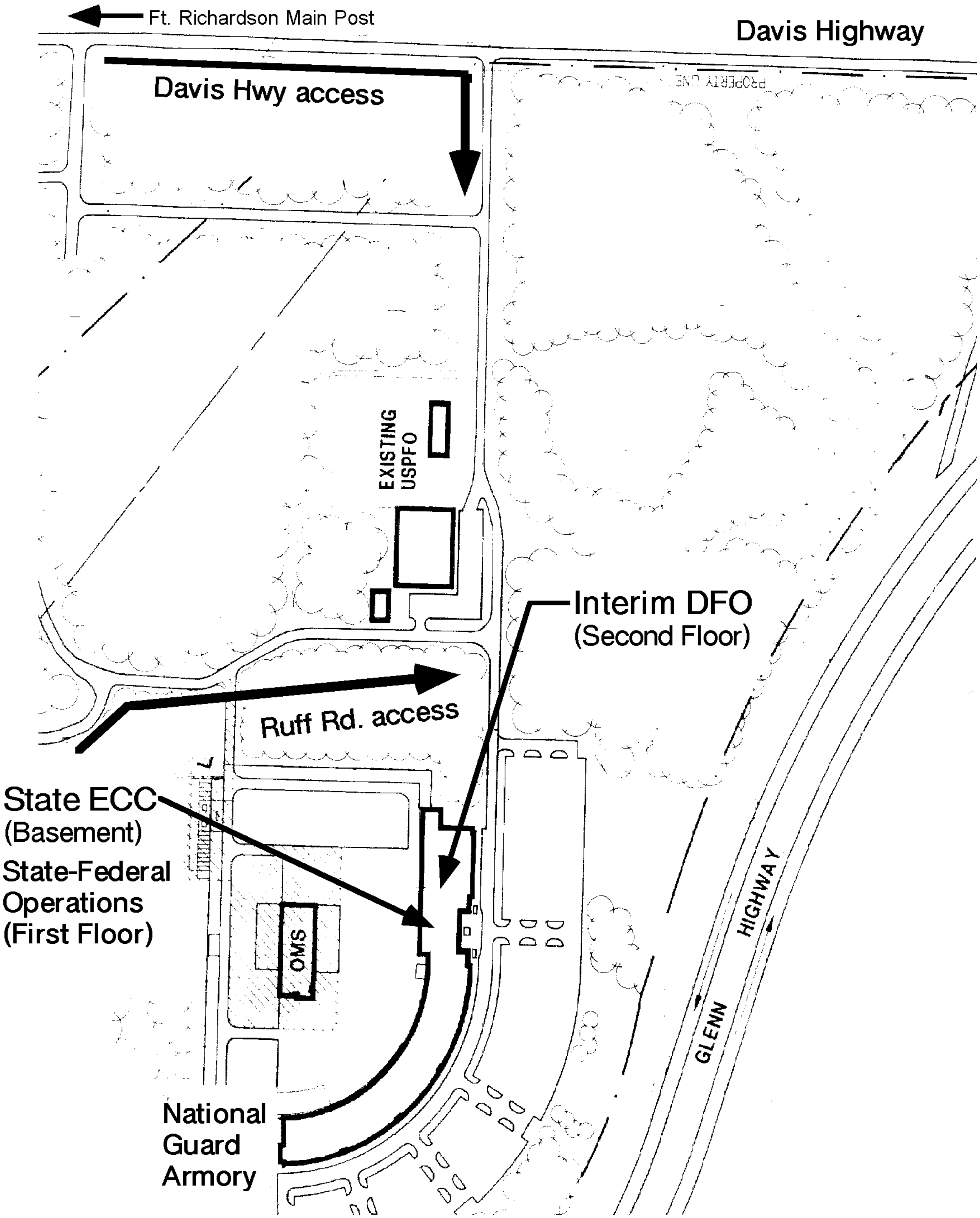
POA Facilities in Anchorage Area



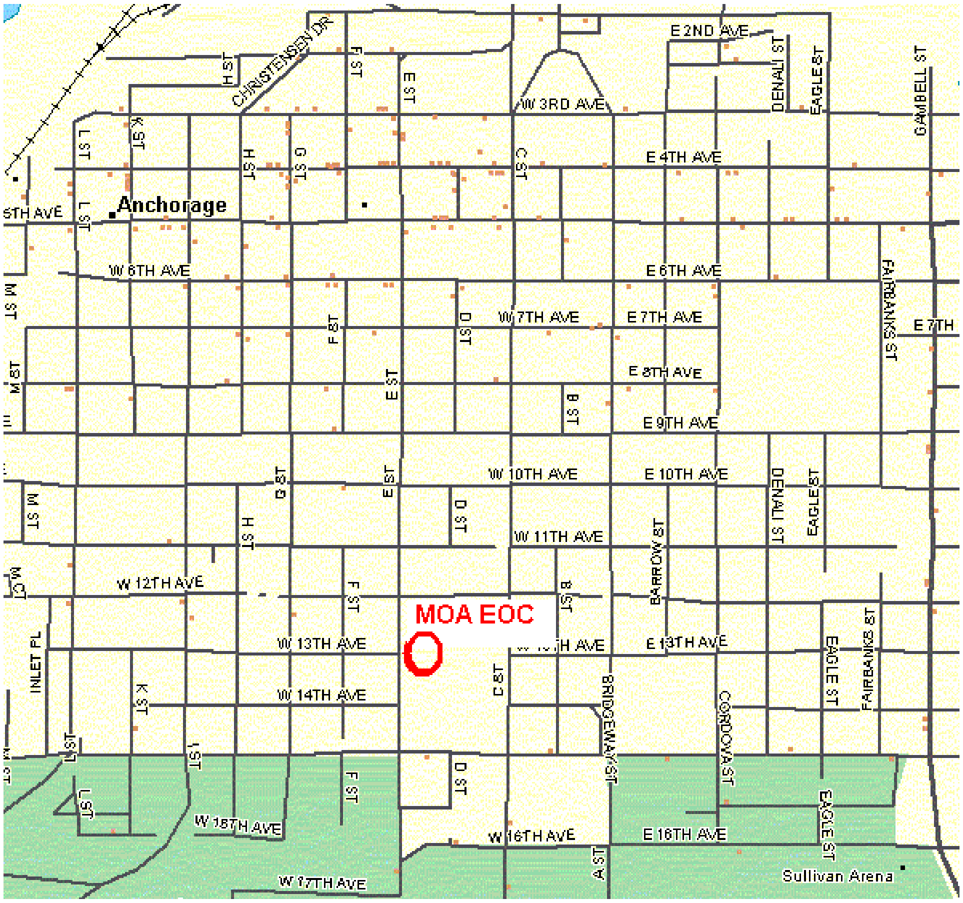
Location of IDFO & SCC



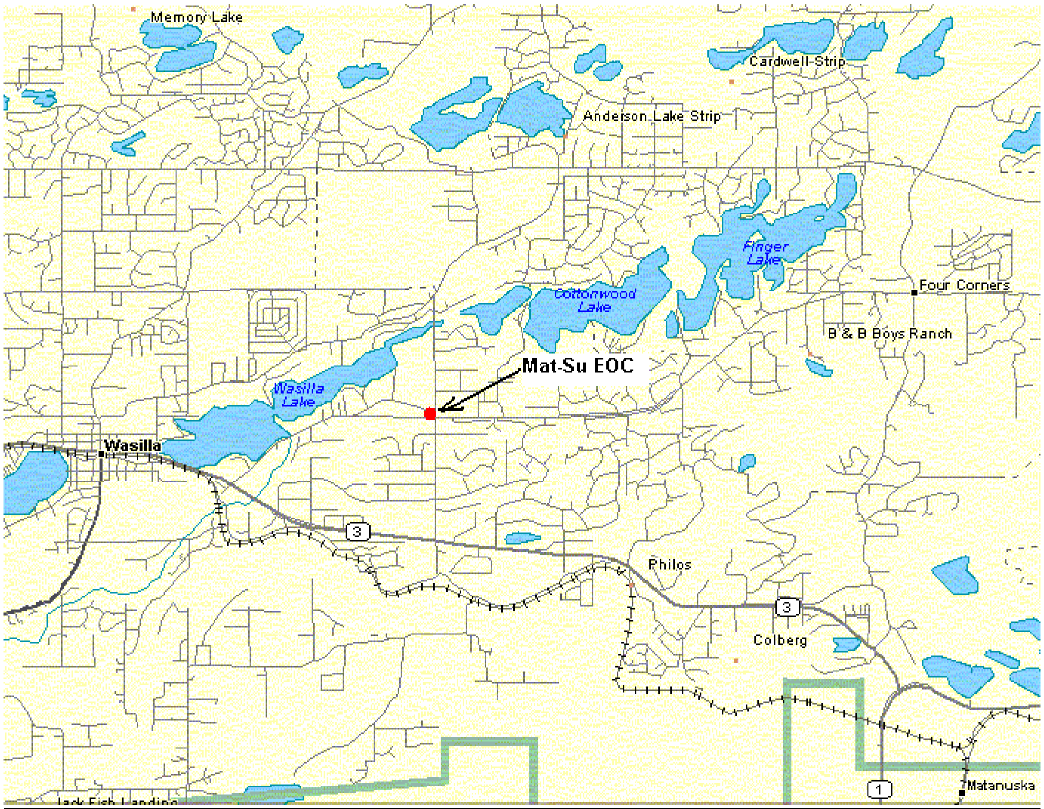
IDFO and SCC


Ft. Richardson Main Post
Davis Highway
Davis Hwy access
PROPERTY LINE
EXISTING USPFO
Interim DFO
(Second Floor)
Ruff Rd. access
State ECC
(Basement)
State-Federal
Operations
(First Floor)
OMS
GLENN HIGHWAY
National
Guard
Armory

Location of Municipality of Anchorage EOC



Location of Matanuska-Susitna Borough EOC

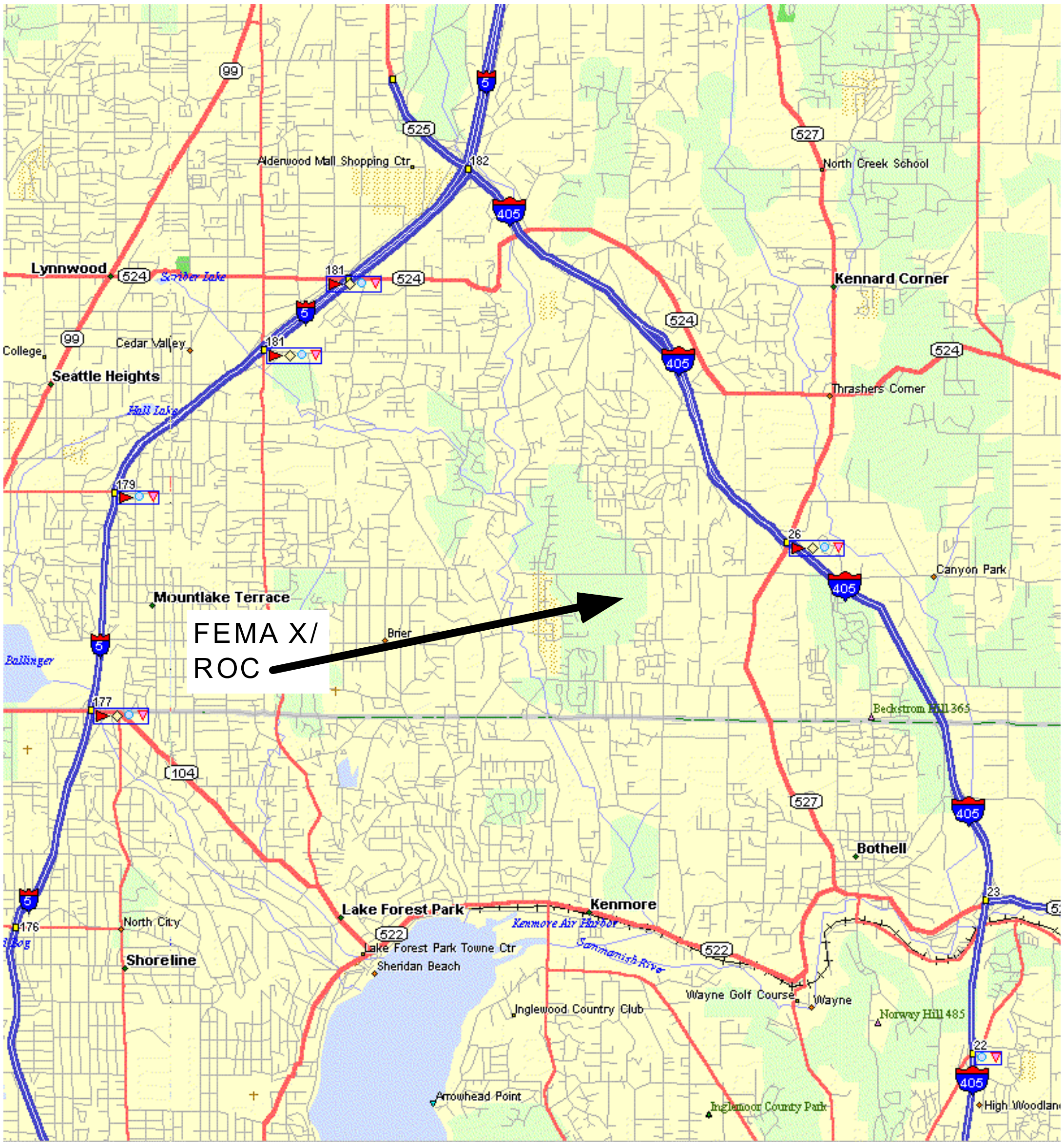


Regional Operations Center (ROC)

General Location

(see next page for close-up of ROC location)

Regional Operations Center (ROC)
General Location



(see next page for close-up of ROC location)

Regional Operations Center (ROC)

Location

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APPENDIX 2 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
ASSESSMENT OF POST-EARTHQUAKE SITUATION

Separate assessments were created, using HAZUS, for the 7.5 shallow crustal earthquake and the 8.0 subduction earthquake. These are presented in Tabs a and b, respectively.

While HAZUS provides a usable approximation of the effects that will occur, the predictions are limited by the accuracy of the default data used by HAZUS. Some of the more significant problems:

a. Shelter requirements for a catastrophic winter earthquake in Anchorage are expected to be far greater than predicted by HAZUS, since few residents will be camping in the yard. (At other times of the year, particularly with the large number of motor homes in the area, the shelter requirements are more realistic.)

b. Hospital damage appears to be overstated, as two of the four local hospitals have been replaced in the last 10 years.

c. Dollar value estimates were not available for damages to utilities, since the data base did not include any information on current value of assets.

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<u>TAB A TO APPENDIX 2 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP</u>
HAZUS PREDICTIONS, 7.5 SHALLOW CRUSTAL EVENT

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Anchorage 7.5
Type of Earthquake	Arbitrary event
Fault Name	Border Ranges
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	149.8 W
Latitude of Epicenter	61.16 N
Earthquake Magnitude	7.5
Depth (Km)	0
Rupture Length (Km)	85.1138
Rupture Orientation (degrees)	30
Attenuation Function	Boor, Joyner & Fumal (1994)

Building Damage

HAZUS estimates that about 40,000 buildings will be at least moderately damaged. This is over 67% of the total number of buildings in the region. There are an estimated 9,612 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 1 below summaries the expected damage by general occupancy for the buildings in the region. Table 2 summaries the expected damage by general building type.

Table 1: Expected Building Damage by Occupancy

	None	Slight	Moderate	Extensive	Complete
Residential	6,809	13,113	20,943	8,630	8,750
Commercial	85	94	341	387	643
Industrial	11	8	56	72	128
Agriculture	0	1	3	3	9
Religion	8	11	26	23	53
Government	0	0	0	0	3
Education	5	0	5	5	26
Total	6,918	13,227	21,374	9,120	9,612

Table 2: Expected Building Damage by Building Type (All Design Levels)

	None	Slight	Moderate	Extensive	Complete
Concrete	47	69	197	244	499
Mobile Homes	58	115	488	1,144	4,774
Precast Concrete	26	13	69	104	204
RM*	43	36	133	171	254
Steel	48	12	93	131	247
URM*	1	0	6	20	149
Wood	6,695	12,982	20,338	7,306	3,485
Total (60,251)	6,918	13,227	21,374	9,120	9,612

*Note: RM Reinforced Masonry; URM Unreinforced Masonry

Essential Facility Damage

Before the earthquake, the region had 808 hospital beds available for use. On the day of the earthquake, the model estimates that only 2 hospital beds (60%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 1% of the beds will be back in service. By 30 days, 8% will be operational.

NOTE: This figure will need to be re-evaluated. It appears the regional data supplied with the model included two hospital buildings that have been replaced within the last 5 years.

Table 3: Expected Damage to Essential Facilities

Classification	Total	Moderate or Greater Damage (>50%)	Complete Damage	>50% Functionality at day 1
Hospitals	7	7	6	0
Schools	168	168	122	0
EOCs	1	1	0	0
Police Stations	5	5	1	0
Fire Stations	7	7	5	0

Transportation and Utility Lifeline Damage

Table 4: Expected Damage to the Transportation Systems

System	Component	Locations/ Segments	At least Moderate Damage	At least Complete Damage	Functionality >50% After Day 1	Functionality >50% After Day 7
Highway	Roads	12	0	0	12	12
	Bridges	143	91	58	46	52
	Tunnels	0	0	0	0	0
Railways	Tracks	53	0	0	53	53
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	1	0	0	1	1
Bus	Facilities	0	0	0	0	0
Port	Facilities	2	0	0	2	2
Airport	Facilities	22	14	2	12	22
	Runways	27	0	0	27	27

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 5-7 provide information on the damage to the utility lifeline systems. Table 5 provides damage to the utility system facilities. Table 6 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 7 provides a summary of the system performance information.

Table 5 : Expected Utility System Facility Damage

System	Total #	W/at Least Moderate Damage	With Complete Damage	With Functionality > 50 After: Day 1	Day 7
Potable Water	0	0	0	0	0
Waste Water	1	1	0	0	0
Natural Gas	2	1	0	0	2
Oil Systems	6	3	0	3	5
Electrical Power	12	10	1	0	10
Communication	53	39	4	33	53
Total	78	54	7	36	70

Table 6 : Expected Utility System Pipeline Damage

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	0	0	0
Waste Water	0	0	0
Natural Gas	0	0	0
Oil	0	0	0
Total	0	0	0

Table 7: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without service at: Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	83,043	81,519	81,482	81,406	80,864	78,010
Electric Power	83,043	73,542	62,951	41,653	10,603	169

Table 8: Expected Communication Facility Functionality

	Total # of	Number of Households with service at:					
	Facilities	Day 0	Day 1	Day 3	Day 7	Day 30	Day 90
Anchorage, AK	53	17.17%	52.88%	74.15%	80.90%	95.46%	99.13%

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 19 ignitions that will burn about 30 sq. mi (0.1% of the region's total area.) The model also estimates that the fires will displace about 600 people and burn about 30 million dollars of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 3.63 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 30% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 145,000 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 15,173 households to be displaced due to the earthquake. Of these, 9,718 people (out of a total population of 226,300) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

· Severity Level 1: Injuries will require medical attention but hospitalization is not needed.

· Severity Level 2: Injuries will require hospitalization but are not considered life-threatening

· Severity Level 3: Injuries will require hospitalization and can become life threatening if not promptly treated.

· Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 9: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Residential	3,578	665	55	55
	Non-Residential	177	34	5	5
	Commute	5	6	11	2
	Total	3,760	706	70	61
2 PM	Residential	815	152	12	12
	Non-Residential	9,407	1,834	249	249
	Commute	24	31	53	10
	Total	10,246	2,017	315	272
5 PM	Residential	968	180	15	15
	Non-Residential	2,835	550	74	74
	Commute	65	85	146	28
	Total	3,868	815	235	117

Economic Loss

The total economic loss estimated for the earthquake is 5.903 billion dollars, which represents 33% of the total replacement value of the region's buildings. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 5.903 billion dollars. 22% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 63% of the total loss. Table 10 below provides a summary of the losses associated with the building damage.

Table 10: Building-Related Economic Loss Estimates

(Millions of dollars)

Area	Residential	Commercial	Industrial	Others	Total
Building Loss					
Structural	540.6	306.1	38.6	45.4	930.6
Non-Structural	2,158.9	634.1	62.8	119.7	2,975.5
Content	428.9	173.9	30.4	30.4	663.6
Inventory	N/A	3.4	3.6	0.2	7.2
Subtotal	3,128.4	1,117.6	135.4	195.6	4,577.0
Business Interruption Loss					
Wage	31.1	225.4	5.7	8.6	270.8
Income	13.2	205.0	4.1	2.8	225.1
Rental	229.6	96.2	2.0	5.6	333.5
Relocation	303.3	135.5	8.3	49.3	496.5
Subtotal	577.2	662.2	20.2	66.3	1,325.9
Total	3,705.6	1,779.7	155.6	262.0	5,902.9

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 11 & 12 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 15 presents the results of the region for the given earthquake.

Table 11: Transportation System Economic Losses

(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	1,334.0	0.0	0.0
	Bridges	179.0	67.5	37.7%
	Tunnels	0.0	0.0	0.0
	Subtotal	1,513.4	67.5	4.5
Railways	Tracks	292.4	0.0	0.3
	Bridges	0.0	0.0	0.0
	Tunnels	0.0	0.0	0.0
	Facilities	3.0	1.0	0.0
	Subtotal	295.1	1.0	0.3
Bus	Facilities	0.0	0.0	0.0
Port	Facilities	3.0	0.0	0.0
Airport	Facilities	125.0	50.4	40.3
	Runways	756.0	0.0	0.0
	Subtotal	881.0	50.4	5.7
TOTAL		2,692.8	118.8	4.4

Table 12: Utility System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	40.5	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	40.5	0.0
Natural Gas	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.8	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	0.8	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	0.0	161.0	0.0
	Subtotal	0.0	161.0	0.0
Electrical Power	Facilities	0.0	350.7	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	350.7	0.0
Communication	Facilities	0.0	45.0	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	45.0	0.0
Total		0.0	598.0	0.0

Table 13. Indirect Economic Impact
(with outside aid)

Year(s)	1	2	3	4	5	6-15	Units
Income Impact	-40	-138	-184	-184	-184	-184	million$
% Income Impact	-0.85	-2.90	-3.85	-3.85	-3.85	-3.85	percent
Employment Impact	67	49	0	0	0	0	#persons
Employment Impact	0.06	0.05	0.00	0.00	0.00	0.00	percent

TAB B TO APPENDIX 2 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
HAZUS PREDICTIONS, 8.0 SUBDUCTION EVENT

HAZUS uses the following set of information to define the earthquake parameters used for the earthquake loss estimate provided in this report.

Scenario Name	Anchorage Matanuska Kenai 8.0 Subduction
Type of Earthquake	Subduction zone
Fault Name	Alaska-Aleutian Megathrust
Historical Epicenter ID #	NA
Probabilistic Return Period	NA
Longitude of Epicenter	150 W
Latitude of Epicenter	61 N
Earthquake Magnitude	8.0
Depth (Km)	20
Rupture Length (Km)	23
Rupture Orientation (degrees)	30
Attenuation Function	Youngs et. al. (1995)

Building Damage

HAZUS estimates that about 18,000 buildings will be at least moderately damaged. This is over 19% of the total number of buildings in the region. There are an estimated 1,374 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS technical manual. Table 1 below summaries the expected damage by general occupancy for the buildings in the region. Table 2 summaries the expected damage by general building type.

Table 1: Expected Building Damage by Occupancy

	None	Slight	Moderate	Extensive	Complete
Residential	51,217	24,702	12,412	3,556	1,213
Commercial	656	288	510	262	128
Industrial	105	39	88	44	25
Agriculture	16	4	4	0	0
Religion	86	26	35	17	7
Government	4	0	0	0	0
Education	52	5	11	3	1
Total	52,136	25,064	13,060	3,882	1,374

Table 2: Expected Building Damage by Building Type (All Design Levels)

	None	Slight	Moderate	Extensive	Complete
Concrete	482	264	402	231	91
Mobile Homes	2,247	1,676	3,249	2,665	1,073
Precast Concrete	176	52	140	78	43
RM*	318	105	179	126	43
Steel	256	62	190	88	42
URM*	37	13	39	50	73
Wood	48,620	22,892	8,861	644	9
Total (95,515)	52,136	25,064	13,060	3,882	1,374

*Note: RM Reinforced Masonry; URM Unreinforced Masonry

Essential Facility Damage

Before the earthquake, the region had 983 hospital beds available for use. On the day of the earthquake, the model estimates that only 163 hospital beds (17%) are available for use by patients already in the hospital and those injured by the earthquake. After one week, 26% of the beds will be back in service. By 30 days, 50% will be operational.

NOTE: This figure will need to be re-evaluated. It appears the regional data supplied with the model included two hospital buildings that have been replaced within the last 5 years.

Table 3: Expected Damage to Essential Facilities

Classification	Total	Moderate or Greater Damage (>50%)	Complete Damage	>50% Functionality at day 1
Hospitals	13	7	0	4
Schools	264	193	0	65
EOCs	3	1	0	1
Police Stations	10	3	0	4
Fire Stations	17	17	0	8

Transportation and Utility Lifeline Damage

Table 4: Expected Damage to the Transportation Systems

System	Component	Locations/ Segments	At least Moderate Damage	Complete Damage	Functionality >50% After Day 1	Functionality >50% After Day 7
Highway	Roads	32	0	0	32	32
	Bridges	291	44	8	275	291
	Tunnels	0	0	0	0	0
Railways	Tracks	64	0	0	64	64
	Bridges	0	0	0	0	0
	Tunnels	0	0	0	0	0
	Facilities	4	0	0	4	4
Bus	Facilities	0	0	0	0	0
Ferry	Facilities	0	0	0	0	0
Port	Facilities	9	0	0	9	9
Airport	Facilities	120	16	1	120	120
	Runways	134	0	0	134	134

Note: Roadway segments, railroad tracks and light rail tracks are assumed to be damaged by ground failure only. If ground failure maps are not provided, damage estimates to these components will not be computed.

Tables 5-7 provide information on the damage to the utility lifeline systems. Table 5 provides damage to the utility system facilities. Table 6 provides estimates on the number of leaks and breaks by the pipelines of the utility systems. For electric power and potable water, HAZUS performs a simplified system performance analysis. Table 7 provides a summary of the system performance information.

Table 5 : Expected Utility System Facility Damage

System	Total #	W/at Least Moderate Damage	With Complete Damage	With Functionality > 50 After: Day 1	Day 7
Potable Water	0	0	0	0	0
Waste Water	0	0	0	0	0
Natural Gas	1	0	0	1	1
Oil Systems	12	3	0	7	12
Electrical Power	5	3	0	1	5
Communication	118	32	1	118	118
Total	137	39	7	127	136

Table 6 : Expected Utility System Pipeline Damage

System	Total Pipelines Length (kms)	Number of Leaks	Number of Breaks
Potable Water	0	0	0
Waste Water	0	0	0
Natural Gas	0	0	0
Oil	238	1	1
Total	238	1	1

Table 7: Expected Potable Water and Electric Power System Performance

	Total # of Households	Number of Households without service at: Day 1	Day 3	Day 7	Day 30	Day 90
Potable Water	107,867	17,106	12,926	5,643	0	0
Electric Power	107,867	64,315	37,387	14,437	768	111

Induced Earthquake Damage

Fire Following Earthquake

Fires often occur after an earthquake. Because of the number of fires and the lack of water to fight the fires, they can often burn out of control. HAZUS uses a Monte Carlo simulation model to estimate the number of ignitions and the amount of burnt area. For this scenario, the model estimates that there will be 4 ignitions that will burn about 10 sq. mi (0.0% of the region's total area.) The model also estimates that the fires will displace about 0 people and burn about 0 million dollars of building value.

Debris Generation

HAZUS estimates the amount of debris that will be generated by the earthquake. The model breaks the debris into two general categories: a) Brick/Wood and b) Reinforced Concrete/Steel. This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 1.38 million tons of debris will be generated. Of the total amount, Brick/Wood comprises 28% of the total, with the remainder being Reinforced Concrete/Steel. If the debris tonnage is converted to an estimated number of truckloads, it will require 55,000 truckloads (@25 tons/truck) to remove the debris generated by the earthquake.

Social Impact

Shelter Requirement

HAZUS estimates the number of households that are expected to be displaced from their homes due to the earthquake and the number of displaced people that will require accommodations in temporary public shelters. The model estimates 4,059 households to be displaced due to the earthquake. Of these, 2,596 people (out of a total population of 306,800) will seek temporary shelter in public shelters.

Casualties

HAZUS estimates the number of people that will be injured and killed by the earthquake. The casualties are broken down into four (4) severity levels that describe the extent of the injuries. The levels are described as follows;

- Severity Level 1: Injuries will require medical attention but hospitalization is not needed.
- Severity Level 2: Injuries will require hospitalization but are not considered life-threatening
- Severity Level 3: Injuries will require hospitalization and can become life threatening is not promptly treated.
- Severity Level 4: Victims are killed by the earthquake.

The casualty estimates are provided for three (3) times of day: 2:00 AM, 2:00 PM and 5:00 PM. These times represent the periods of the day that different sectors of the community are at their peak occupancy loads. The 2:00 AM estimate considers that the residential occupancy load is maximum, the 2:00 PM estimate considers that the educational, commercial and industrial sector loads are maximum and 5:00 PM represents peak commute time.

Table 8: Casualty Estimates

		Level 1	Level 2	Level 3	Level 4
2 AM	Residential	804	136	12	12
	Non-Residential	63	12	1	1
	Commute	1	1	2	0
	Total	868	149	15	13
2 PM	Residential	201	34	3	3
	Non-Residential	2,928	540	70	70
	Commute	4	5	8	2
	Total	3,132	578	81	74
5 PM	Residential	239	40	4	4
	Non-Residential	988	183	24	24
	Commute	11	14	24	5
	Total	1,238	237	51	33

Economic Loss

The total economic loss estimated for the earthquake is 2.242 billion dollars, which represents 6% of the total replacement value of the region's buildings. The following three sections provide more detailed information about these losses.

Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the earthquake. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the earthquake.

The total building-related losses were 2.2423 billion dollars. 25% of the estimated losses were related to the business interruption of the region. By far, the largest loss was sustained by the residential occupancies which made up over 53% of the total loss. Table 9 below provides a summary of the losses associated with the building damage.

Table 9: Building-Related Economic Loss Estimates
(Millions of dollars)

Area	Residential	Commercial	Industrial	Others	Total
Building Loss					
Structural	146.9	138.8	18.3	18.6	322.6
Non-Structural	679.8	289.5	31.7	45.8	1,046.8
Content	180.9	103.1	17.3	15.6	316.9
Inventory	N/A	2.1	2.1	0.1	4.2
Subtotal	1,007.6	533.5	69.4	80.1	1,690.6
Business Interruption Loss					
Wage	14.7	107.7	2.6	3.9	128.9
Income	6.2	99.2	1.9	1.2	108.6
Rental	76.1	50.4	1.2	2.4	130.1
Relocation	81.7	74.6	5.5	22.0	183.7
Subtotal	178.7	331.9	11.2	29.5	551.3
Total	1,186.3	865.3	80.6	109.6	2,241.8

Transportation and Utility Lifeline Losses

For the transportation and utility lifeline systems, HAZUS computes the direct repair cost for each component only. There are no losses computed by HAZUS for business interruption due to lifeline outages. Tables 10 & 11 provide a detailed breakdown in the expected lifeline losses.

HAZUS estimates the long-term economic impacts to the region for 15 years after the earthquake. The model quantifies this information in terms of income and employment changes within the region. Table 12 presents the results of the region for the given earthquake.

Table 10: Transportation System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Highway	Roads	10,181.3	0.0	0.0
	Bridges	403.0	14.5	3.6
	Tunnels	0.0	0.0	0.0
	Subtotal	10,584.3	14.5	0.1
Railways	Tracks	677.4	0.0	0.2
	Bridges	0.0	0.0	0.0
	Tunnels	0.0	0.0	0.0
	Facilities	12.0	1.1	9.3
	Subtotal	689.4	1.1	0.2
Bus	Facilities	0.0	0.0	0.0
Ferry	Facilities	0.0	0.0	0.0
Port	Facilities	13.5	0.0	0.0
Airport	Facilities	834.0	63.1	0.0
	Runways	3,752.0	0.0	0.0
	Subtotal	4,586.0	63.1	1.4
TOTAL		15,873.2	78.7	0.5

Table 11: Utility System Economic Losses
(Millions of dollars)

System	Component	Inventory Value	Economic Loss	Loss Ratio (%)
Potable Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	0.0	0.0
Waste Water	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.0	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	40.5	0.0
Natural Gas	Pipelines	0.0	0.0	0.0
	Facilities	0.0	0.1	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	0.8	0.0
Oil Systems	Pipelines	0.0	0.0	0.0
	Facilities	0.0	96.6	0.0
	Subtotal	0.0	96.6	0.0
Electrical Power	Facilities	0.0	66.8	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	66.8	0.0
Communication	Facilities	0.0	34.4	0.0
	Distribution Lines	0.0	N/A	N/A
	Subtotal	0.0	34.4	0.0
Total		0.0	197.9	0.0

Table 12. Indirect Economic Impact
(with outside aid)

Year(s)	1	2	3	4	5	6-15	Units
Income Impact	-13	-48	-64	-64	-64	-64	million$
% Income Impact	-0.23	-0.80	-1.08	-1.08	-1.08	-1.08	percent
Employment Impact	21	26	0	0	0	0	#persons
Employment Impact	0.02	0.02	0.00	0.00	0.00	0.00	percent

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APPENDIX 3 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
RESOURCES

1. **Contractors.** POA Contracting Division maintains a bidders list, which identifies those contractors who have expressed an interest in obtaining contracts from the Corps in Alaska. If POA-CT is not operational, the list may be accessed . . .

2. **Construction Materials.** While there are several major suppliers of construction supplies in Anchorage, they do not have the stocks needed to respond to a catastrophic earthquake. Stockage tends to be highest in the early summer, and lowest at the end of the calendar year (to minimize tax liability). Based on the EXXON VALDEZ experience, local individuals and businesses will quickly buy up the available supplies. Most construction materials will need to be obtained from stocks in the Puget Sound area, or elsewhere in CONUS. For the response period, transportation will need to be coordinated through the ROC/DFO, due to the many urgent requirements for limited air and sea transportation. The NARC will assist in purchasing and shipping materials and equipment.

APPENDIX 4 TO ANNEX B TO ANCHORAGE EARTHQUAKE CDRP
RESIDUAL CEPOA CAPABILITIES

1. The Alaska District currently has approximately 575 employees, with approximately 75 employees living in Fairbanks/North Pole and Juneau. Based on normal workforce statistics, about 30 employees would be expected to commute from the Matanuska-Susitna Borough.

2. 7.5 shallow crustal: Based on general population figures, approximately 140 employees would have extensive or complete damage to their homes; an additional 170 would be dealing with moderate damage. Of the remaining 190 employees with slight or no damage to their homes, 30 would be from the Matanuska-Susitna Borough and would initially encounter access problems. In cold weather, even those with no home damage might still need to take emergency steps to drain pipes to prevent extensive plumbing damage in the event of a power outage. Based on HAZUS projections, during the work day there would be 5 persons killed or hospitalized and another 18 requiring medical attention but not hospitalization. Outside the work day, this would drop to 1 or 2 killed or hospitalized and 7 requiring medical attention but not hospitalization. Additional employees would be unavailable because of similar injuries to family members; however, this is approximately balanced by the employees who would be counted twice above (unavailable due to both injuries and residence damage). Based on these figures, the Alaska District would be a “victim district” with approximately one-third effective strength available during the initial disaster period.

3. 8.0 subduction: Based on general population figures, approximately 20 employees would have complete or severe damage to their homes; 70 would have moderate damage, while 410 would have slight or no damage. Counting all levels of medical treatment, and both employees and their family members, the loss would be under 10 persons during non-duty events and under 20 for duty events. In this circumstance, Alaska District would be capable of conducting its regular missions but would require some TDY support to replace personnel unavailable due to injuries/residence damage, to replace employees who are diverted to Federal Response Plan missions, and to handle disaster-related workload from existing customers. Alaska District would not be capable of organizing an ERRO.